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BMP

Report of Survey Conducted at

MASON & HANGER SILAS MASON CO., INC.

MIDDLETOWN, IOWA

JULY 1994

BEST MANUFACTURING PRACTICES

Center of Excellence for Best Manufacturing Practices

PREFACE

During the week of July 18, 1994, a Best Manufacturing Practices (BMP) survey was conducted at Mason & Hanger (M&H) - Silas Mason Co., Inc. at the Iowa Army Ammunition Plant (IAAP) in Middletown, Iowa. M&H is the country's longest-existing engineering and construction company. The IAAP is a 19,000-acre load, assembly, and pack facility that provides munitions and high explosives development, processing, production, testing, and demilitarization. The plant encompasses 1.7 million square feet of manufacturing space and 1.9 million square feet of warehouse area, for a total of over 4.3 million square feet within the confines of the facility. These efforts are supported by almost 1,000 M&H personnel.

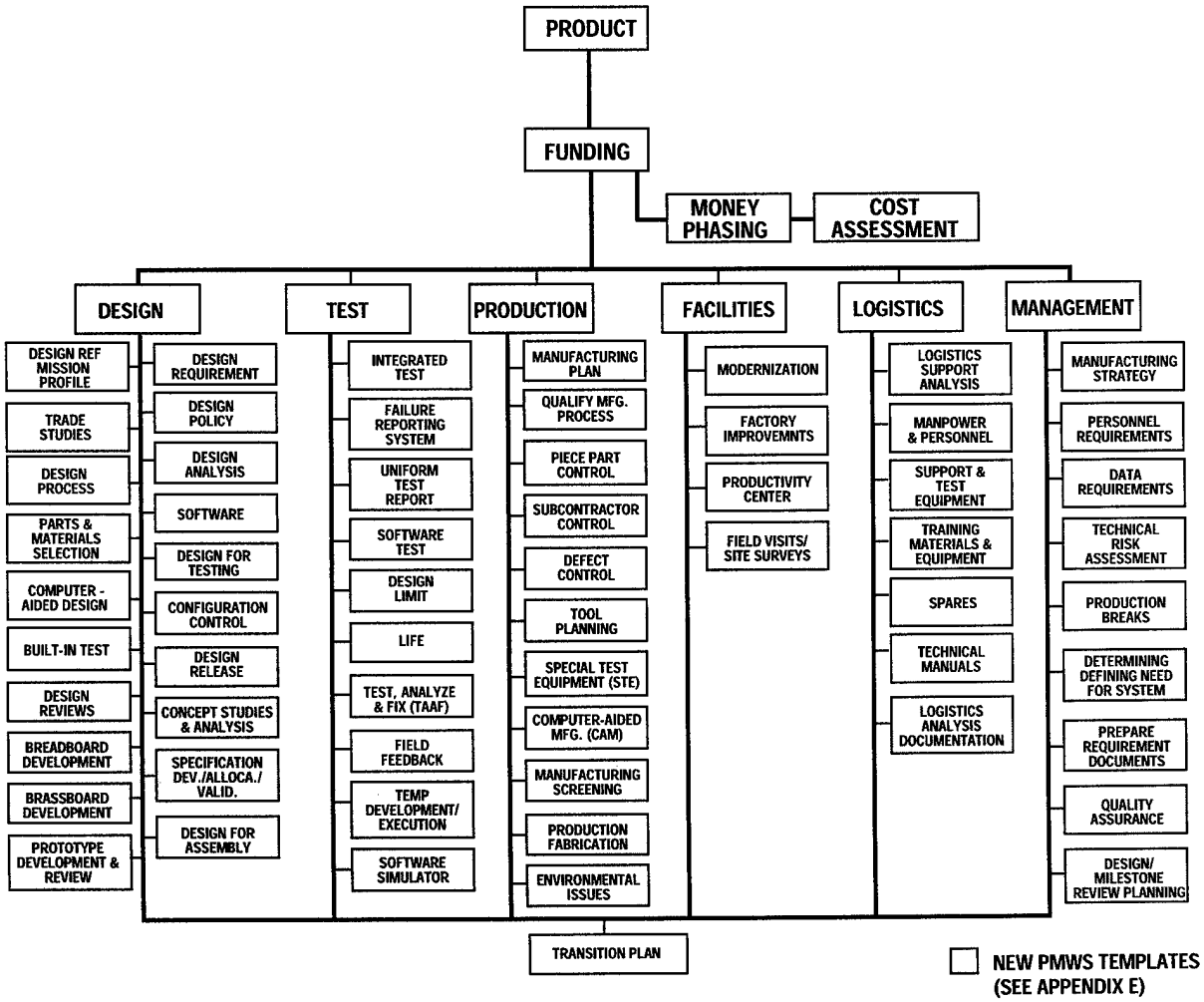
The IAAP facility is recognized as a leader in the high, medium, and low volume production of pressed or melt-poured warheads such as Hellfire, TOW, Patriot, Stinger, Dragon, and Hawk. The facility also produces 120mm battle tank ammunition and a variety of mines, rocket-assisted artillery rounds, demolition charges, and blanks. Named as the Midwest Area Demilitarization Facility in 1992, IAAP now has a primary mission of disposing of old and/or obsolete ammunition in an environmentally-conscious manner.

To aggressively meet the challenge of the downsizing climate, M&H puts emphasis on quality, and this attitude permeates every aspect of not only what the company does, but also monitoring and measuring how well it is done. Mason & Hanger's quality management system is one of the most extensive ever documented by the BMP program. This system is supported by two critical components that help gauge its success — the benchmarking program and the performance indicator system.

BMP surveys are conducted to identify best practices in one or more of the critical path templates of DoD 4245.7-M), "Transition from Development to Production." This document provides the basis for BMP surveys that concentrate on areas of design, test, production, facilities, logistics, and management. Practices in these areas and other areas of interest are presented, discussed, reviewed, and documented by a team of government engineers who are invited by the company to evaluate the company's policies, practices, and strategies. Only non-proprietary practices selected by the company are reviewed. In addition to the company's best practices, the BMP survey team also reviews potential industry-wide problems that can be referred to one of the Navy's Manufacturing Technology Centers of Excellence. The results of the BMP surveys are entered into a database for dissemination through a central computer network. The actual exchange of detailed data is between companies at their discretion.

The Best Manufacturing Practices program is committed to strengthening the U.S. industrial base. Improving the use of existing technology, promoting the introduction of enhanced technologies, and providing a noncompetitive means to address common problems are critical elements in achieving that goal. This report on Mason & Hanger will provide you with information you can use for benchmarking and is part of the national technology transfer effort to enhance the competitiveness of the U.S. Industrial Base.

"CRITICAL PATH TEMPLATES FOR TRANSITION FROM DEVELOPMENT TO PRODUCTION"



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SECTION 1

EXECUTIVE SUMMARY

1.1 COMPANY OVERVIEW

In business since 1827, Mason & Hanger (M&H) - Silas Mason Co., Inc. is the country's longest-existing engineering and construction company. Originally involved in large construction and landmark infrastructure projects, M&H accomplishments include: the Grand Coulee Dam; the Lincoln, Boston, and Brooklyn-Battery auto tunnels; and New York City Subway tunnels.

Mason & Hanger entered the ordnance plant construction arena during World War II and set industry standards for blast resistant structures and explosives safety procedures. Its engineers developed new technologies for automated processing and new methods for melting, curing, and shaping explosives in the load/assembly and pack operations. In 1947, Mason & Hanger began construction of a Nuclear Weapons line at the Iowa Army Ammunition Plant (IAAP) in Middletown, Iowa for the Atomic Energy Commission. M&H became the IAAP operating contractor for the U.S. Army in 1951. It continues to operate this government-owned, contractor-operated facility and refine its ability to efficiently manufacture products critical to national defense.

The IAAP (Figure 1-1) is a 19,000-acre load, assembly, and pack facility that provides munitions and high explosives development, processing, production, testing, and demilitarization. The plant encompasses 1.7 million square feet of manufacturing space and 1.9 million square feet of warehouse area, for a total of over 4.3 million square feet within the confines of the facility. Also included are 142 miles of roads and 103 miles of railroad tracks. These efforts are supported by almost 1,000 M&H personnel.

The IAAP facility is recognized as a leader in the high, medium, and low volume production of pressed or melt-poured warheads such as Hellfire, TOW, Patriot, Stinger, Dragon, and Hawk. The facility also produces 120mm battle tank ammunition and a variety of mines, rocket-assisted artillery rounds, demolition charges, and blanks. Named as the Midwest Area Demilitarization Facility in 1992, IAAP now has an additional mission of disposing of old and/or obsolete ammunition in an environmentally-conscious manner.

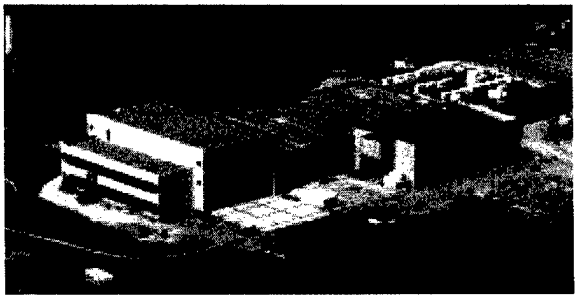

FIGURE 1-1. IOWA ARMY AMMUNITION PLANT

As with all defense related activities and companies, M&H has faced serious challenges to its survival. To aggressively meet the challenge, Mason & Hanger put the emphasis back on the basic ingredient to success - *quality*. "Quality is an attitude" definitively describes all facets of business at M&H. This attitude permeates every aspect of not only what the company does but more importantly, monitoring and measuring how *well* it is done. Mason & Hanger's quality management system is one of the most extensive ever documented by the BMP program. This system is supported by two critical components that help gauge its success — the benchmarking program and the performance indicator system.

An effective and aggressive benchmarking program is the first factor in M&H's outstanding quality related effort. M&H recognizes that to become world class, it needs to determine comparability standards. The company actively searches for data on world class processes and practices that is used to realize substantial process improvements. M&H not only searches for this information, but innovatively adapts key features for its own use or in some instances, even enhances it. Knowing where the company stands in the national and world marketplace is crucial to realizing and securing a share of commerce.

The performance indicator system, a centralized metrics retrieval/reporting system, is M&H's tool to track current status, change effects, and progress. This comprehensive system provides a set of indicators for over 600 different areas as a means to assess and set goals for the company's continuous improvement efforts. All personnel actively apply these indicators in areas from customer satisfaction, cycle time, and quality, to timeliness and productivity. By contributing to and continually measuring continuous improvement, M&H employees go beyond "ownership" typical of many successful continuous improvement processes and programs. They know they represent the pivotal element to the company's success.

This complete assimilation of the quality attitude into the company culture has resulted in numerous quality awards

for Mason & Hanger including its certification by the U.S. Army Armament, Munitions and Chemical Command under its Contractor Performance Certification Program. This same command has stated that M&H is "Number One in Product Quality." In addition, the company has received quality awards from the State of Iowa, Rockwell International, Loral Aeronautic, Martin-Marietta, and several U.S. Army commands. The continued growth of its quality efforts was recognized in 1993 and 1994 when Mason & Hanger was a semifinalist for the Manufacturing Category - Malcolm Baldrige National Quality Award, an award the company is vying for again in 1995.

Mason & Hanger and the IAAP — called Team Iowa — represent the very best in quality programs and continuous improvement. By successfully recognizing and applying the two important elements of benchmarking and quality management through its personnel, Team Iowa stands well positioned to provide other companies new standards by which to measure themselves. The BMP Survey Team found the following practices to be among the best in industry and government.

1.2 BEST PRACTICES

The following best practices were documented at Mason & Hanger:

1.3 INFORMATION

The BMP survey team identified the following information areas at Mason & Hanger:

1.4 ACTIVITY POINT OF CONTACT

For further information on any item in this report, please contact:

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SECTION 2

BEST PRACTICES

2.1 PRODUCTION

MANUFACTURING PLAN

Alternative to Shop Floor Engineered Standards

During the 1970s and 1980s, Mason & Hanger (M&H) employed a large staff of Industrial Engineering Technicians and Industrial Engineers (IEs) to maintain stopwatch standards required by contractual requirements for production work. Detailed time study sheets and process sheets were maintained for all active production items, weekly efficiency reports were generated on standards, and variance reports were generated detailing efficiencies below 90% or above 110%.

This information was used to rate employees, their performance, and establish production quotas. The use of stopwatch time studies generated conflicts between production personnel and IEs, and these time studies were labor intensive, sometimes requiring 60-80 hours per work area. Production personnel had no ownership of the standards, and it was difficult for IEs to maintain good working relationships with production personnel. As part of M&H's TQM effort in the late 1980s, this situation was addressed by examining the concept of negotiated standards. The prime contractor agreed to the concept and modified the contract to remove the MIL-STD-1567A requirement.

In developing a negotiated standard, the production engineer generates a detailed breakout of steps for a process, broken out by work stations. The production engineer defines the planned shift rate based on schedule requirements and bottleneck areas, and meetings are held with production/quality supervision, program management, and production engineering. After each step is discussed and staffing levels are determined, a spreadsheet is generated using planned shift rate and staffing levels. Table 2-1 is an example of a negotiated standard calculation.

There are substantial benefits to this approach of determining negotiated standards, including:

1. Production supervision, quality supervision, and program management have an agreed-upon work standard.
2. Decisions include supervision and program management.
3. Working relationship between production engineer, production supervisor, and operator is improved.
4. The standard only acts as a baseline and is easily changed as processes change and supports continuous improvement.
5. There is a reduction in engineering manpower required to set standards.
6. Teamwork is promoted.
7. Engineering workload on standards is reduced by 50% or more.

TABLE 2-1. EXAMPLE OF NEGOTIATED STANDARD CALCULATION

• **UNITS PER SHIFT**	=	**100**
• **HOURS PER SHIFT**	=	**10**
• **PRODUCTION OPERATOR STAFFING**	=	**4**
• **INSPECTION STAFFING**	=	**1**
• **TOTAL CREW SIZE**	=	**5**
• **RUNTIME/UNIT = 10 HOURS/100 UNITS**	=	**.1 HOUR/UNIT**
• **PRODUCTION STANDARD = .1 HOUR/UNIT X 4 OPERATORS**	=	**.4 MANHOUR/UNIT**
• **INSPECTION STANDARD = .1 HOUR/UNIT X 1 INSPECTOR**	=	**.1 MANHOUR/UNIT**
• **TOTAL STANDARD = .4 MANHOUR/UNIT + .1 MANHOUR/UNIT**	=	**.5 MANHOUR/UNIT**

The next step planned by M&H personnel in this process is to include the production operators in negotiated standards meetings. This step will help to further develop teamwork and ownership of processes and production requirements.

PRODUCTION FABRICATION

Explosives Pressing Technology

A combination of capable facilities, an experienced engineering and operating staff, a commitment to continuous improvement, and process technology development has made the M&H explosives processing technology world class. Although originally constructed to provide the capability to pour TNT-based explosives into artillery shells, the IAAP also maintained a limited explosive pressing capability for pellets, boosters, and leads needed for the artillery shells. In the 1950s, the Department of Energy (then the Atomic Energy Commission) established a pressed explosives line at the M&H-run facility. When that operation moved in 1965, an experienced workforce and the facilities for pressing explosives remained at the Iowa facility. As munitions technology advanced, precision-shaped charges and explosively-formed penetrator-type warheads became necessary to defeat multiple targets. These requirements for precision munitions were initially met by pressing oversize billets to the proper density and machining the explosive to final critical dimensions.

More recently, M&H has pioneered the development of plastic-bonded explosives pressing to net or near net dimensions. The company now maintains a unique and impressive capability built on more than 50 presses ranging in size from a 100-ton capacity to 800-ton capacity equipped with state-of-the-art process controllers, an experienced staff of tooling design engineers, process engineers and press operators, and experience with both traditional and new, insensitive explosives. Explosives are pressed in hydraulic presses to obtain a pressure of 20,000 psi on the explosive surface to obtain a charge that is 98% of maximum theoretical density and meets critical geometric requirements to tolerance as low as ±0.004 inch. A combination of SPC, improved tooling design, enhanced press control, and press cycle improvements have allowed M&H to consistently manufacture high quality explosive charges.

For example, continuous improvement activities have resulted in a doubling of the penetration performance of the Hellfire warhead while reducing the performance standard deviation by half. In the TOW 2B, the performance improvement has been almost 10% over the past three years. The process yields have also improved from 80-90% in the late 1980s to 98% for the period from 1989 through 1992 for the TOW 2A, thereby reducing scrap costs. The Hellfire scrap costs were reduced by 67% from 1989 to 1993.

ENVIRONMENTAL ISSUES

Groundwater Monitoring Program

An M&H groundwater monitoring review resulted in M&H examining its processes for establishing well locations, acquiring groundwater samples, and evaluating data from more than 30 wells located at IAAP. As a result of the review, M&H corrected water table elevation data on several wells and installed additional wells where needed to monitor a landfill site.

A critical benefit from the 1992 review of the groundwater monitoring program is the identification of improved processes for obtaining groundwater samples. Because the composition of the water in a well changes as it stands for months, the well must be purged and allowed to refill just prior to taking the groundwater sample. M&H found that rapid purging of the well caused changes in the pH of the groundwater samples such that they were no longer representative of the actual groundwater values. M&H similarly found that the groundwater sample bottle must be filled in a particular manner in order to obtain repeatable data - seemingly insignificant items such as rapidly pouring the water sample into the bottle or wiping off the threads of the bottle can have a major impact on the quality of the groundwater sample and resulting data. For example, a 1991 set of total organic carbon data from a well (consisting of four data points) could be interpreted that the "correct" value was either 3 ppm or 15 ppm. A similar set of 1993 data following the improvement of the sampling process shows more consistency, with all values ranging between 1.0 ppm and 1.6 ppm.

As a result of the review of groundwater sampling practices, M&H has found that scrupulous care is required in all groundwater sampling actions, and that consistency in work patterns is critical. Detailed groundwater sample acquisition plans have been developed and are carefully followed to ensure high quality data, that can then be used with confidence for monitoring and remediation purposes. M&H also realized a spillover benefit as a result of the groundwater sampling process improvements, as a better understanding of the importance of careful and repeatable techniques has also resulted in the improvement of other laboratory processes.

Environmental Emergency Response Team

M&H used a videotape system to train a 37-member hazardous material emergency response team. This training

program was developed in response to escalated OSHA standards for using and handling hazardous materials. Initial M&H compliance was through an Operations Training course conducted by the U.S. Army at Ft. Benning, Georgia in 1989. However, because of the limited number of training spaces available, M&H realized that this course would not meet its needs.

A 1990 course in Hazardous Material Emergency Response trained over 100 people, but the training was limited to spill containment and not cleanups. Beginning in January 1991, M&H purchased a series of videotape training courses which were provided to the fire department personnel. Although adding the videotape capability provided training for all fire department personnel, there were only four of the trained people on site at any one time - not considered enough to handle a serious emergency.

To alleviate the difficulty with insufficient manpower, a search for additional personnel to become trained was initiated in September 1993. The search was complicated by union work interests, medical requirements, and job classifications. Therefore, the emergency response team member position was designated a voluntary collateral duty. From these volunteers, a team was selected to include safety, environmental, material, explosive waste, mechanical, and government personnel. This team's training was completed in June 1994 after a three-month period of two, three-hour classes per week. In addition to 15 fire department personnel, there are now 22 volunteers that are fully trained to the emergency response technician level. A Hazardous Material Emergency Response Trailer has been purchased and stocked with personal protective equipment and necessary cleanup and decontamination supplies.

M&H is currently the only facility in the area with a fully trained emergency response hazardous materials team that can completely mitigate accidental release of a variety of hazardous materials. The team continues to train through the Fire and Emergency Television Network, as well as through a yearly mock disaster drill. The team also employs state-of-the-art equipment such as infrared thermal imaging to help locate and mitigate spills. This approach has allowed M&H to come into full compliance with the law using an efficient and cost effective video training process.

Benign Manufacturing

M&H set an industry standard by eliminating the open burning of explosive and explosive-contaminated hazardous waste. Since the early 1980s, the facility has successfully applied two procedures using a closed system incinerator with a proven record of performance.

The first of these is the contaminated waste processor which is a closed system incinerator for disposal of explosive-contaminated material such as paper, wood, and metal. The process involves loading the waste into a pan which is placed in the incinerator. Using a combination of propane and diesel fuel, the temperature in the incinerator is brought to the proper temperature for oxidation of any contaminants and held at that temperature for the time required for their complete destruction. Exhaust gases are cooled, passed through a cyclone separator and a bag house to remove any particulates before being discharged into the atmosphere. Particulate material is tested to ensure that it is no longer hazardous and disposed of by landfilling.

The second system deals with explosive wastes which are similarly treated in a closed system rotary kiln. The explosives are remotely fed to the kiln in small containers. The kiln is heated with propane and diesel fuel to maintain the temperature necessary to combust the explosives. Waste gases first go through an afterburner to ensure complete combustion, then through a cyclone and bag house to remove any particulates before discharge to the atmosphere.

Use of these systems has enabled M&H to continue manufacturing operations in an environmentally friendly manner.

Energy Conservation

A presidential Executive Order issued in March 1994 instructed federal agencies to reduce overall energy use in federal buildings by 30% by the year 2005 from 1985 energy use levels; increase overall energy efficiency in industrial federal facilities by 20% by 2005 using 1990 as the baseline year; and minimize use of petroleum products at federal facilities by switching to less-polluting alternative energy sources. It also directed agencies to design and construct new facilities to minimize life-cycle costs through energy efficiency and water conservation technologies and use passive solar design and active solar technologies wherever cost effective.

Prior to this event, the IAAP had already undertaken an energy conservation program that met or exceeded the goals called for in the Executive Order. In 1985, Mason & Hanger formed the IAAP Energy Council, chaired by the Facilities Engineering Energy Manager, with a main goal to reduce energy use throughout the facility and eliminate unnecessary overhead or operating costs. Members of the council included the engineering division manager, mechanical division manager, operations division manager, transportation and services manager, a representative from the comptroller, and bargaining unit representatives. The Council met quarterly to review past accomplishments and develop new initiatives which would meet their charter.

This program has accomplished many milestones including the establishment of an energy monitor program through

which volunteer employee monitors identify targets of opportunity to reduce energy usage. The facility also converted to gasohol use in M&H's fleet of vehicles for an annual savings of over 10,000 gallons of gasoline. Building consolidation studies are ongoing, as well as an active review of all new construction and renovation at the facility with emphasis toward energy efficiency. The establishment of a dynamic energy resource management plan has been established, and the work week of the employees was modified from an eight-hour, five-day to 10-hour, four-day work week.

Through the efforts of the employees at M&H, the IAAP documented energy cost avoidance of over $1.32M during the period of FY85 through FY93 (See Figure 2-1). IAAP has adopted the policy of reducing the demand for energy as being immediately more effective than increasing the supply.

2.2 MANAGEMENT

MANUFACTURING STRATEGY

Benchmarking

Mason and Hanger (M&H) continually compares its practices against those from the best organizations in the world and adapts key features of those practices to its own organization. This process provides comparability standards for M&H to match, and helps identify areas for process improvement initiatives.

The main thrust of M&H benchmarking efforts is focused on information obtained through the resources of the International Benchmarking Clearinghouse (IBC), the Navy's Best Manufacturing Practices (BMP) Program, and The Benchmarking Exchange (TBE). Heavy emphasis is placed on intensive research and networking with world class organizations. These efforts are spearheaded by a company benchmarking champion who pulls together published information and develops benchmarking contacts and potential benchmarking partners. Networking is pursued by developing linkages through the IBC, BMP, and TBE electronic networks and making contacts through active participation in numerous professional organizations. An extensive library of articles and publications on processes of interest is maintained. Information from all sources and benchmarking studies is combined to compile world class performance indicators that are compared against internal performance indicators and used to identify processes for improvement. An internal operating procedure document provides guidelines for conducting benchmarking. Figure 2-2 illustrates how compiled information has been used to

	ENERGY MEGA BTUs		FY93 DOLLARS	
	USE	REDUCTION FROM PREVIOUS YR.	COST	PREVIOUS YR.
FY85	796,372	-0-	$3,218,185	-0-
FY86	784,594	11,778	$2,404,775	$ 813,410
FY87	824,653	(40,059)	$2,551,062	(146,287)
FY88	804,861	19,792	$2,441,303	$ 109,759
FY89	762,330	42,531	$2,356,582	$ 84,720
FY90	715,557	46,773	$2,225,709	$ 130,873
FY91	655,474	60,083	$2,060,191	$ 165,518
FY92	635,255	20,219	$2,003,045	$ 87,146
FY93	617,097	18,158	$1,897,979	$ 105,066
				$ 1,350,205

FIGURE 2-1. IAAP ENERGY COST AVOIDANCE FY85 THROUGH FY93

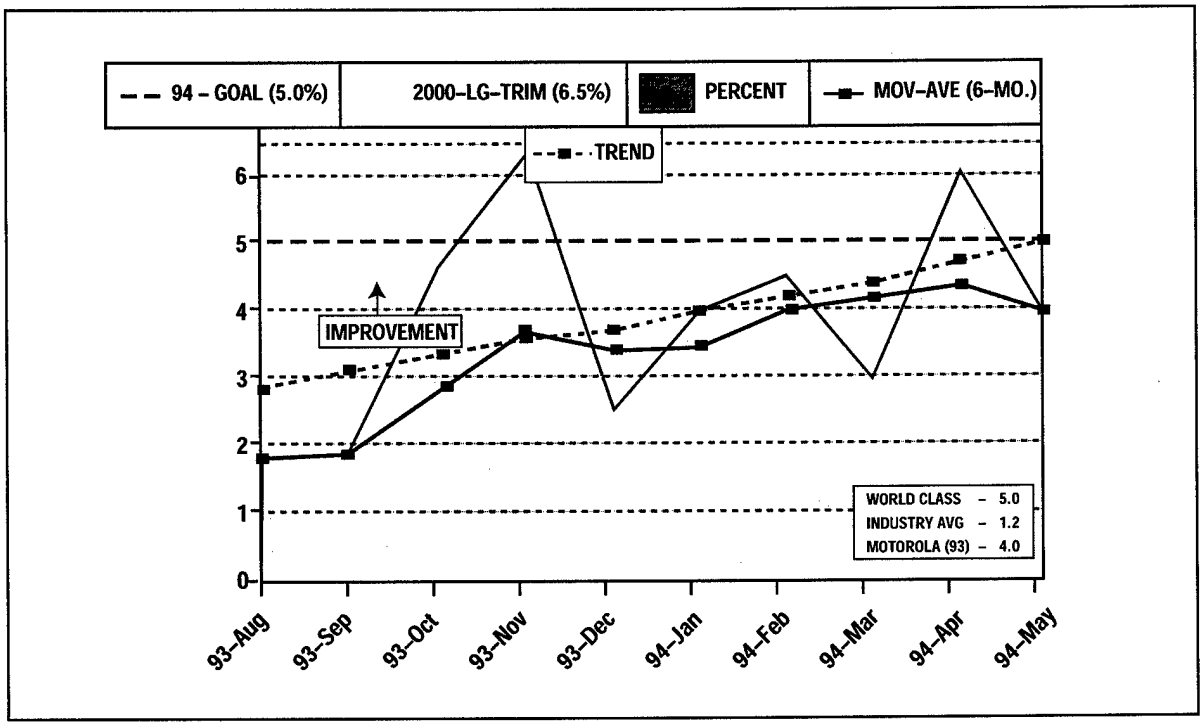


FIGURE 2-2. TRAINING DOLLARS PER PAYROLL DOLLAR (%)

compare M&H's performance indicator for training dollars as a percentage of total payroll with world class and industry averages.

Formal benchmarking studies have been undertaken in a wide variety of key business process areas with many other companies (Table 2-2). Other benchmarking activities have included formal studies with a large group of companies. An example of this is an M&H-sponsored benchmarking survey of corporate legal departments to identify best practices in preventive law programs. Companies involved in this study included Eastman Kodak, Chase Manhattan Bank, ITT Defense and Electronics, Allstate Insurance, Sandia Corporation, Westinghouse Savannah River Company, and Battelle Memorial Institute.

The benchmarking process gives Mason & Hanger a competitive advantage. It drives continuous improvement efforts and provides the capability to achieve major gains in key processes as the pace of change, and its effect on survival in business becomes ever more rapid.

Performance Indicator System

Performance indicators are sets of tailored metrics which are used extensively by M&H to assess continuous

TABLE 2-2. BENCHMARKING STUDIES

ACTIVITY/PROCESS	COMPANY
CONFIGURATION MANAGEMENT	KDI PRECISION
SAFETY PROGRAM	SQUARE D COMPANY
FORWARD RATE PRICING AGREEMENTS	CERIDIAN DCAA
STORAGE SDS GRID SYSTEMS	LETTERKENNY ARMY DEPOT
DOCUMENT CONTROL	ALLIANT TECHSYSTEMS ITT DEFENSE
TOTAL PRODUCTIVE MAINTENANCE	LIBBY OWENS FORD ITT DEFENSE
CUSTOMER SATISFACTION PROCESS	EASTMAN CHEMICAL
BILLING & ACCOUNTS PAYABLE	LOCKHEED
PAYROLL SERVICES	LOCKHEED
TRAVEL & EXPENSE REPORTS	LOCKHEED
DCAA RELATIONSHIP	TEXAS INSTRUMENTS
MATERIALS MANAGEMENT	APICS MONMOUTH COLLEGE ITT DEFENSE
EMPLOYEE ATTITUDE SURVEYS	TEXAS INSTRUMENTS
SUPPLIER CERTIFICATION PROGRAM	TEXAS INSTRUMENTS

improvement, establish current status, monitor the effects of changes, and determine progress. These indicators encompass the full business spectrum from customer satisfaction, cycle time and quality, to timeliness and productivity.

Driven by the M&H Continuous Improvement Board, the use of performance indicators expanded from a total of 40 indicators in April 1992 to over 600 in May 1994. During this growth period, Mason & Hanger developed a mainframe tracking system to retrieve and report the metrics data from a centralized performance indicator source. Individuals can request a performance indicator as a means to assess and set goals for continuous improvement efforts. The request goes to the centralized performance indicator source which typically retrieves the data from the plant's Information Facility System and presents it in a color-coded chart format which is prominently posted and distributed on a monthly basis.

The implementation of a centralized Performance Indicator source has relieved the burden placed on the requester to design and maintain his own system and has standardized the process of reporting throughout M&H. This has substantially reduced the cost of reporting, and increased the use of performance indicators which have become a critical tool for monitoring continuous improvement efforts.

Business Process Reengineering

Mason & Hanger has implemented an active business process reengineering effort to identify and effect radical redesign of business processes to achieve major gains in cost, service, or time. In November 1993, the company produced an internal operating procedure document for reengineering key business processes. This document describes the procedures to systematically improve key business processes. It provides guidelines for how a key business process team is started, how a process is defined, how it is streamlined, how it is measured and controlled, and how it is continuously improved.

Two Business Process Reengineering Team (BPRT) efforts are underway. The Material Planning and Control BPRT is reengineering the planning and production control system by reducing requirements, changing systems, and developing a world class planning and control system. Improvements are expected to reduce the planning and control system cost per direct labor hour by 60% for a projected annual savings of more than $400K. The General Supply BPRT is radically redesigning the process by which all general supply material is requisitioned, procured, paid for, stocked, and issued. It is well on its way to reducing the general supply administrative costs by at least 60%. Other BPRTs are forming and taking aim at key processes with the goal of achieving world class status in each process.

A major element designed to ensure the success of the reengineering process is the rewards and recognition system which supports the reengineering process. It is a six-level system to provide cash awards and other recognition for BPR teams and individual team members. The first year that a business process is recognized as world class, each BPRT member receives a special contribution award of up to $10K. Smaller dollar amounts and formal recognition is awarded for lower levels of achievement.

Other key enablers of the reengineering process are effective benchmarking, research, and networking processes that keep Mason & Hanger cognizant of global business process improvements. By tracking world class practices in key business areas and comparing these to its own extensive internal performance indicators, the company can target the best areas for improvement and know with confidence how much improvement it can expect to attain.

Value Engineering

Mason & Hanger recognizes that Value Engineering can offer reductions in the cost of doing business by applying proven techniques to the design and manufacturing process. Process action teams, comprised of people who know the process, analyze and brainstorm new ways of performing the task at a reduced cost and with more efficiency. This effort involves reducing the number of parts used, revising procedures, and updating support services.

Mason & Hanger has long applied value engineering techniques and has a 30-year history of performance against goals that has produced savings of over $100M. Value Engineering Change Proposals (VECPs) — usually product related — change specifications, regulations, or drawings and can be requested by any employee. They must be derived from a VE study. Savings obtained through their application are shared by the customer with Mason & Hanger. Value Engineering Proposals are used to change methods and do not have to be product related. Unlike VECPs, the customer does not receive a share of the savings. The savings must be in "hard" dollars, and the proposal must have resulted from a value engineering study.

Value Engineering was applied to the Volcano weapon program, and the cost of operations was reduced through manufacturing process improvements and product design. A team of representatives from engineering, production, management, quality and a VE coordinator brainstormed and identified 13 items. Studies were conducted which reduced the final number of recommendations to the one that addressed the major cost driver. Total VE savings submitted by this one team equaled $482K.

PERSONNEL REQUIREMENTS

Safety Compliance Program

Safety systems at Mason & Hanger are extensive and include participation and awareness by every company employee. Written policies and a strong awareness of the work environment are integrated throughout all systems with strong, active support by top management.

The written policies include the Plant Manager Policy that emphasizes employee, committee, and team priority and responsibility for safety, and the Written Safety Procedure that defines the activities of the safety program such as OSHA compliance, responsibilities, training, safety promotion, employee involvement, investigating and reporting, and continuous improvement.

Even though regulations have become more stringent, M&H maintains stable costs for its safety programs. M&H's strong safety performance environment and aggressive program has been recognized by the receipt of the U.S. Armament Munitions and Chemical Command "Safety Award of Merit."

Training Database

Mason & Hanger conducts over 190 training courses for a labor force of approximately 1000 personnel in more than 313 different job classifications. Courses are categorized into Mandatory (by law, government regulation, or contract), Required (to perform the job), and As Needed (to enhance the job). Each area requires different levels of tracking, reporting, and traceability. To streamline the administration of these courses, M&H installed an automated Training Database System.

The previous manual training administration and monitoring system was labor intensive, contaminated with inaccurate and incomplete records, and lacked sufficient detail. The system was not an efficient traceability documentation, reporting, and scheduling system. As a result, M&H was not certain that personnel were receiving training in an efficient and effective manner.

Mason & Hanger completed a two year effort to fully automate its training administration and monitoring practices. Detailed catalog content, history, certification, and scheduling information was loaded in a TIF database. The new database allows easy retrieval of an in-depth description of course content, length of course, who can teach, course number, and category. Data can be retrieved on course location, who received training, what was taught and when. Schedules can be established months in advance and serve as a timetable for out-year training. The database is used to track who needs training, when it is required, and what is required for the training. Reports from the history database can be retrieved to satisfy any reporting requirement.

This Training Database System has improved the administration of the training program at Mason & Hanger. Training transactions, scheduling, and reporting are virtually error-free and performance has been optimized.

Office Supply Ordering System

Inventory practices were successfully improved by M&H's implementation of an Office Supply Ordering System. By centralizing and streamlining its office supply ordering system, M&H was able to alleviate accumulated inventory, release capital, eliminate the need for large amounts of valuable space, and avoid extensive monitoring and inventory control resources.

The previous office supply ordering practice required each department to requisition and issue supplies, and involved many steps, resources, and time. Requisitions were sent to the warehouse, and transportation and labor were required for distribution. A clerk would input information to the inventory system, requisitions were again initiated for inventory replenishment, and a buyer would issue purchase orders to the vendor. A material checker would then receive and stock material awaiting next issue.

Implemented in April 1994, the new Office Supply Ordering System was designed for one vendor to take the entire order. Only one purchase order is negotiated and issued each year, and each department forwards orders directly to the vendor. Orders placed by Monday noon are delivered by the vendor each Wednesday morning to eight centralized locations. The delivery invoice is checked by the requestor and a copy forwarded to accounts payable. Accounting then debits each department for the items it orders, and vendor payments are made monthly.

The new system has reduced invoices from 140 to 12 per year — 90%. Only one purchase order is negotiated per year instead of the 84 individual purchase orders issued in 1993. Stores inventory is no longer required. Material checker and clerical time, purchasing time to negotiate and issue purchase orders, and accounts payable transactions have been reduced or eliminated. Dollars tied up in office supply inventories have been virtually eliminated.

360° Feedback Performance Appraisal/ Merit System

To overcome the limitations of traditional performance appraisal systems in a team environment, M&H has developed a unique performance appraisal system based on inputs from peers and customers. This system, called the 360 Degree Feedback System, is used to determine merit

pay. It was developed and implemented in June 1992 in the 150-person Materiel Division as a pilot for the entire plant.

The need for a new approach to employee performance appraisal arose as Mason & Hanger adopted a team concept and recognized that traditional performance appraisal systems did not work well in a team environment. Team leaders become the primary customers because they controlled merit increases under the traditional system. These systems did not measure the most important internal and external customer perceptions, were subject to too much reviewer bias, and promoted individualism instead of teamwork.

The 360 degree peer/customer appraisal approach (developed by the Materiel Division) gives a reliable, valid, and credible appraisal keyed to actual performance while enhancing teamwork. Initially, the appraisal form utilized the existing human resources appraisal format and performance evaluation categories. These have been modified several times based on employee feedback and benchmarking data from other companies. Participation is mandatory for an employee to be considered for merit pay. The employee randomly chooses three internal customers, three external customers, and completes a self review. Random selection of reviewers is left to the honor of the employee, and reviewers are not required to sign the appraisal form. Feedback provided to the employee includes copies of the seven reviews including all comments, a summary report showing the ratings and averages in each evaluation category, a report showing averages for the team, a division averages report, and a documented explanation of how the system works.

Copies of the seven reviews plus a document signed by the employee indicating receipt and understanding of the reviews is retained in the employee's human resource personnel file. Surveys of the employees using this approach have indicated that employees liked this system over the traditional system, considered it to be fair, and believed they learned more about their performance than before.

The merit portion of the system seeks to evaluate performance criteria that employees control and maximize the use of objective data over opinion. Its objective is to associate merit results to customer feedback and other emphasized criteria. Four weighted evaluation measures were established - peer/customer performance evaluation (50%), action item system responsiveness (25%), initiative/involvement (15%), and work effort (10%). After determining the score for each of the four evaluation measures for each employee, the scores are added to obtain an overall score. Performance zones (Above, Average, and Below) are established, and the overall score is normalized to place an employee in the appropriate performance zone from which the determination of merit increase is made. Employees receive a documented explanation of the merit system, notification of the merit increase (percent change, dollar change, new salary), and a summary report (total points received, performance position, comments). Although not mandatory, either the division team leader or the employee can request a face-to-face review.

The 360 Degree Feedback system has been well received by employees and management and is effectively meeting performance appraisal requirements in a team environment. Future directions include plant-wide adoption and more emphasis on team performance.

Wellness Center

Mason & Hanger established a Wellness Center in 1988 to help address the rising health care cost of the work force. Originally designed to primarily focus on the physical aspects of the employees with a concentration on fitness testing and cardiovascular screening, the Center has since emphasized the "whole person" to maintain a healthy workforce.

In 1992 the Wellness Center added a wellness professional and a lab technician staff to coordinate programs and emphasize the condition of the whole employee. Activities now include a blend of :

- On-site exercise facilities
- Fitness classes
- Personal counseling
- Health education activities
- Preventive health testing
- Life-style improvement classes
- Health incentive programs
- A wellness library available to employees and their families.

The exercise facilities are open 24 hours a day with a flexible staff supervision to accommodate any work shift. Based on its success and need, the Wellness Center maintains future plans to continue staff education, increase the variety and scope of the programs, improve communication of wellness activities, and expand the Center to meet the increased demands for counseling, training, and exercise facilities.

Employee awareness of the Wellness Center and its activities has risen since the 1992 expansion. Participation in activities has correspondingly grown from 350 per month in September 1992 to 650 per month in May 1994. The number of employees and family members using the Wellness Center facilities has increased from 300 to 500 per month during the same time frame.

Quality Management System

The M&H Quality Management System (QMS) helps efficiently utilize resources by graphically identifying opportunities for quality improvement or cost reduction to managers and technical personnel. The QMS is a mainframe computer-based quality information system designed and programmed by Mason & Hanger personnel to provide automated information reporting support. The original defect tracking portions of the QMS (statistical process control, quality engineering, and short/long term product quality tracking) were first put into operation in 1989 with additional major capabilities in cost of quality, supplier management, material review, corrective action tracking, audit planning, and performance measurement metrics implemented in 1991.

The QMS uses statistical tools (such as statistical process control, Pareto analyses, trend data, and P-charts) for the analysis of production data to provide engineering and management focus for process improvements. QMS data is available throughout the plant, with approximately 500 terminals located in the production areas to allow for data entry and retrieval. The QMS tracks over 3300 characteristics daily, and can provide over 400 screens of data or reports.

The QMS has helped M&H improve a variety of operations including supplier management, quality engineering, audit planning, and short- and long-term product quality tracking. Supplier performance is reviewed not only at incoming inspection, but also in terms of additional difficulties encountered throughout the entire production process, allowing for accurate determination of lowest total cost (best value) suppliers. The time required for preparation of monthly and lot-end quality reports has decreased from one to two weeks down to less than two hours. By helping close the informational loop on review of nonconforming material, appropriate corrective actions are taken on out-of-spec materials and processes - resulting in a reduced number of required material review board actions. The QMS maintains the status of over 450 standard operating procedures, manufacturing instructions, quality control standards, and administrative practices and procedures. The system tracks over 7000 gauges for re-calibration dates, and adjusts calibration intervals based on historical performance trends. Short- and long-term product quality is also tracked by the QMS. Short term quality consists of the latest 32 actual production shifts for any given product, and long term quality data covers the past four years.

The QMS provides M&H engineering and management with a valuable tool that helps keep the organization focused on quality. It assures that details such as corrective action responses, recertifications, and gauge recalls are not forgotten. It efficiently covers all quality areas and allows management to apply scarce human and financial resources based on factual statistical data, instead of opinion. In the five years that the QMS has been in use at IAAP, scrap costs per direct labor hour have decreased from $7/hour to $1/hour, on-time contract deliveries have increased from 76% to 97%, and total quality cost savings have accumulated to $18.5M.

Cost of Quality

The Cost of Quality System provides M&H management with the information needed to help minimize total quality cost, and consequently, helps direct management decisions. M&H engineering, supervisory, and management personnel have on-line access to the Cost of Quality System, and it is used as a primary report card to gauge the results and effectiveness of specific initiatives. The system is based on the American Society of Quality Control book *Principles of Quality Costs*, as well as an internal Mason & Hanger quality control standard procedure. Quality costs are tracked in four categories — Prevention, Appraisal, Internal Failure, and External Failure. Examples of some of the prevention costs include training, design, audits, quality planning and supplier activities; appraisal cost activities include inspection, source inspection, and testing; internal failure cost activities include supplier corrective actions, material review board, scrap, and rework costs; and external failure cost activities include returned goods and customer complaints.

As a part of M&H's Quality Management System, the Cost of Quality System prepares graphical reports illustrating plant-wide quality costs, plant-wide defect trends, item quality costs (total or per unit), and comparisons of different production lines. The format of the graphs can be selected to depict total quality cost trends for prevention, appraisal, and failure costs; quality costs normalized by production direct labor hours, total cost, or per unit cost; pie charts of prevention, appraisal, and failure costs; or a similar series of charts for defects categorized and displayed as minor, major, and critical. Plant-wide costs related to quality can also be compared, sorted, or ranked by any of the data input fields. Trend data is calculated monthly and depicted on individual graphs, allowing adverse trends to be easily identified and corrective action to be initiated as appropriate.

The Cost of Quality System is a valuable tool extensively used by M&H's engineering and management to identify opportunities for reduction in quality costs. Use of the Cost of Quality reporting system has resulted in IAAP monthly costs associated with quality being reduced from $593K in late 1989 to $327K in mid-1994. During this same time frame, the costs related to quality per direct production labor hour dropped from $20/hour to $8/hour. These cost

reductions were accomplished concurrently with a substantial increase in the overall product mix, which also required an increased amount of testing (a quality appraisal cost item) of the newer product lines.

Process Acceptance by SPC

To maintain a competitive edge and become a world class munitions manufacturer, M&H is constantly improving processes, reducing manufacturing costs, and ensuring product quality. To accomplish this, all employees are given an introductory 32 hours of training in TQM-SPC within the first six months of their employment. With this awareness and skills training, the personnel are continually searching for long term solutions to process problems during their daily work. When any employee identifies a target of opportunity for improvement, the idea is submitted to the Continuous Improvement Board for approval to form a Process Action Team (PAT) to investigate the opportunity and develop a solution to the process problem.

The personnel on the PAT include the production workers, engineers, management, and maintenance personnel that will be implementing the process acceptance improvement. The PAT prepares detailed process flow diagrams, establishes controlling factors of the process, identifies measures for these controlling factors, and gathers the appropriate data and charts it. The first step to improving the process is to allow the process to run without any adjustment to see if the process is in control and capable of meeting the specifications. If the process is in control and capable, a design of experiments is instituted to determine how variation of inputs affects process outputs. Data from this variation is gathered and measured. Based on the results of this controlled change, the process may be further altered or left alone. If the change shows promise, a long term process capability study is performed. This study allows the process to run normally for 20 or more shifts. The data collected is then calculated against the specifications to determine if the process is capable in the long term. If the customer agrees that M&H is controlling the process, "normal" inspection is ceased. Acceptance using SPC takes over, changes to the process are based on control chart data, and "prevention replaces detection."

Process Acceptance-SPC replaced the following items at Mason and Hanger:

- Technical Data Package AQL
- MIL-STD-105E
- MIL-STD-414
- Continuous Inspection Sampling
- Batch Sampling
- Defect Detection Systems.

Elimination of 15 inspections in the 40-pound cratering charge program resulted in a $90K cost savings, eight manhours per shift reduction in inspection time required to accept the product, and a 14% productivity increase. Additionally, 250 inspections on seven other programs have been replaced by Process Acceptance-SPC.

SPC Process/Product Acceptance has increased process predictability/reliability, increased customer confidence, decreased cost, and increased the IAAP market share of the munitions business.

SECTION 3
INFORMATION

3.1 DESIGN

DESIGN PROCESS

Machine Design Process

M&H initiated a structured design procedure to improve engineering productivity by shortening the cycle time involved to design new machines or resolve other manufacturing equipment problems. This initiative was implemented through M&H's Methods Engineering (ME) group which was tasked with the design and development of any new machines or equipment required for the production of explosive devices.

The ME group was previously tasked with many intermediate-size projects that came with a preconceived idea of what exactly was required, as well as the final form of the design. An essentially intuitive design methodology was being used by the requesting organization, without allowing sufficient insight to system requirements by ME.

In February 1994, the ME group instituted a structured design methodology procedure to focus on three main areas:

1. Identify the problem. This first step involves clarifying the task — what the problem is really about, what are the implicit and explicit wishes and expectations of the solution, and what properties the solution must not have.
2. Determine the available solution requirements or boundaries. The second step involves developing a solution-neutral problem statement that will allow for a broader range of solution options, instead of focusing the design on an intuitive solution to the problem. For example, instead of "Install a dust collection system," a solution-neutral problem statement would state "Eliminate the dust hazard."
3. Solve the problem within the solution boundaries. Step 3 centers on developing a listing of both mandatory and desired properties of the design solution.

After completing these steps, the more traditional project planning and design processes can begin. All preliminary review tasks are identified on a task verification checklist that must be completed prior to receiving approval to proceed with the design effort.

By thoroughly evaluating the requirements of design tasks, unnecessary/repeat design activities will be eliminated. In one example cited, M&H avoided three months of design time and $10K in costs by fully analyzing the problems associated with air flow in a paint booth.

3.2 PRODUCTION

QUALIFY MANUFACTURING PROCESS

Real Time Radiographic Inspection System

M&H uses an Automated Inspection Device for Explosive Charge in Shell (AIDECS) system to provide a real-time x-ray analysis capability and automated defect detection and accept/reject decision. Each projectile system at the M&H Iowa Army Ammunition Plant undergoes a 100% radiographic inspection required by MIL-STD-453. This inspection checks for cracks, porosity, low density areas, base separations, or foreign material in melt-cast loaded projectiles — critical defects that impede the safe performance of a munition. Currently, individual projectiles are x-rayed by film in both zero-degree and 90-degree rotations. The film is developed on-site and analyzed by x-ray technicians. The quality of this safety-critical inspection process is dependent upon a subjective evaluation of the film based on the experience of the technician. The manual film reading process results in a delay in determining whether a projectile meets the system requirements for x-rayed defects.

To address this issue, M&H has installed the AIDECS, developed by the Science Applications International Corporation. The system is designed to provide real time x-ray analysis as well as automated defect detection and accept/reject decisions. A Varian model L200A 2.0 MeV x-ray source is combined with a six-station automated turntable, Cesium-Iodide x-ray imager screen, and a high resolution Silicon Intensified Target camera. This equipment is enclosed in a lead-shielded cabinet for attendant operation. The data from the camera is sent to a control system that regulates the operations, processes digitized image data, projects the image on a screen, archives data on both tape and optical disk, and prints hardcopy reports. The system automatically scans the projectile in zero and 90 degree rotation, analyzes the x-ray image, locates and defines any defect detected, compares those defects to the acceptance criteria for the projectile, and classifies the projectile as accept or reject.

A prove-out project for this equipment is underway to validate the AIDECS x-ray method. This project is using the M913 105mm RAP projectile as the test system. Inert projectiles with known defects have been manufactured to test the ability of the system to discriminate and quantify defects. The validation process will consist of comparing the x-ray film process to the AIDECS image for live projectiles. The goals established for the AIDECS system include indicating 0% false accepts and a maximum of 2% false rejects. This criteria will ensure that no safety critical defects are accepted. This system has the potential to reduce the cost of this critical inspection process at M&H and reduce the chance that an error in reading the film will result in a defective projectile being shipped.

SUBCONTRACTOR CONTROL

Supplier Management and Certification Program

M&H is using a three-level supplier certification program at the Iowa Army Ammunition Plant to reduce in-house inspection required and improve on-time delivery percentages for production items.

Mason & Hanger began using a three-level supplier certification program at the Iowa Army Ammunition Plant in January 1994. The first level of certification is achieved on a part-by-part basis by scoring a minimum of 85% on a grading scale consisting of quality, delivery, and service items. At this level, M&H benefits by being able to reduce the amount of required incoming inspection, and the supplier benefits through a speedier payment process. The second level certification requires that the supplier pass an audit conducted by M&H personnel, as well as having all supplied parts meet first level certification requirements. At this level, M&H transfers inspection responsibilities to the supplier, and the supplier may be given a 5% price consideration over non-certified suppliers. The third level certification requires that the supplier uses SPC in the production and acceptance of products supplied to M&H, as well as meeting all the requirements for the second level certification. When requested, M&H will help the supplier establish an SPC program for the supplier's production items. Anticipated benefits of this certification level include that the use of SPC will drive down part costs for M&H, and that the supplier may be given a 10% price consideration over non-certified suppliers.

Since the inception of the program, 53 parts and 22 suppliers have achieved first level certification status, and three suppliers are currently pursuing second level certification. M&H has also been actively pursuing a best value procurement focus and has reduced its active supplier base for production items from approximately 100 to approximately 50. M&H is also developing a certification program for service contractors.

ENVIRONMENTAL ISSUES

Employee Physical Safety

Employee safety and accident prevention are major concerns at M&H, and the company has gone beyond the requirements of OSHA in training and accident prevention in the areas of Confined Space Entry procedures, Lockout/Tagout procedures, and Asbestos Abatement/Inspection processes.

In each area, the applicable federal law, state law, and OSHA requirements have been studied and training developed for employees. M&H has also developed internal Administrative Practices and Procedures (AP&P) that are used for employee safety training. In most cases, the AP&P goes beyond the requirements of the applicable Code of Federal Regulations. For example, one requirement defines the different levels of confined space, and indicates what safety precautions shall be taken when entering each level. The local AP&P does not differentiate between low hazard confined space and potentially hazardous confined spaces when entry is required. "Permitting" is required for entry into each of these areas, and the same safety precautions are taken. In addition, the AP&P clearly defines the duties and responsibilities of all personnel affected by the procedure and the exact process to follow in performing the procedure. The AP&Ps for the areas of lockout/tagout and asbestos abatement are equally as comprehensive and the level of training and requirements for retraining are equally stringent.

3.3 FACILITIES

FACTORY IMPROVEMENTS

Integrated Management Information System

The Integrated Management Information System (IMIS) at M&H, brought on-line in 1990, links manufacturing, logistics, and engineering. A financial management system was added in 1991 to enhance the MRPII capability which includes capacity planning, shop floor control, purchasing, and simulation. IMIS is used to accurately define product structures, plan materials, track inventory, reduce errors, and provide accurate production schedules.

Previously, a variety of outmoded hardware and software accomplished the functions now implemented centrally on IMIS. Access to vital information was slow because of

overnight batch processing, and two to three days were required for turnaround on corrections. The lack of integration resulted in frequent data entry duplication and required multiple interfaces for users to know. Material requirements planning and work orders were done manually by planners. There was little data sharing between organizations. In the financial area, it took three weeks to close out the books at the end of each month and up to three months to close the year-end books. Audit trails were not adequate to meet DCAA requirements.

IMIS was developed as part of Mason & Hanger's strategy to remain competitive and survive in an environment of declining defense funds and fewer defense suppliers. To be competitive the company realized it had to meet the customer's schedule, control costs, be responsive to the customer, and satisfy DCAA's material management accounting system requirements. This required a current, accurate, and complete management information system.

The systems and functions managed and integrated in IMIS include purchasing and accounts payable, material inventories, and all material and labor reporting activities for shop floor control. Processing is done in real time versus batch updating. Benefits of the system include on-line data entry validation that has virtually eliminated error correction down time, precise contract tracking, improved accuracy, real time feedback to material planners, and faster program modifications and development. In the financial area, monthly and yearly closeout times have been reduced by nearly 70%, on-line production cost statements are available daily, and audit trails are greatly improved. All costs, purchase orders, inventory records, and work orders, are now identified and tracked by program.

IMIS runs on a Hitachi Model EX31 mainframe computer (Figure 3-1). There are over 400 terminals and PCs and 145 printers throughout the site that are all networked to the mainframe. An E-mail system is used for communication and allows employees the flexibility of working while away from the plant. Other systems such as the Quality Management System are also running on the Hitachi and will be integrated into IMIS.

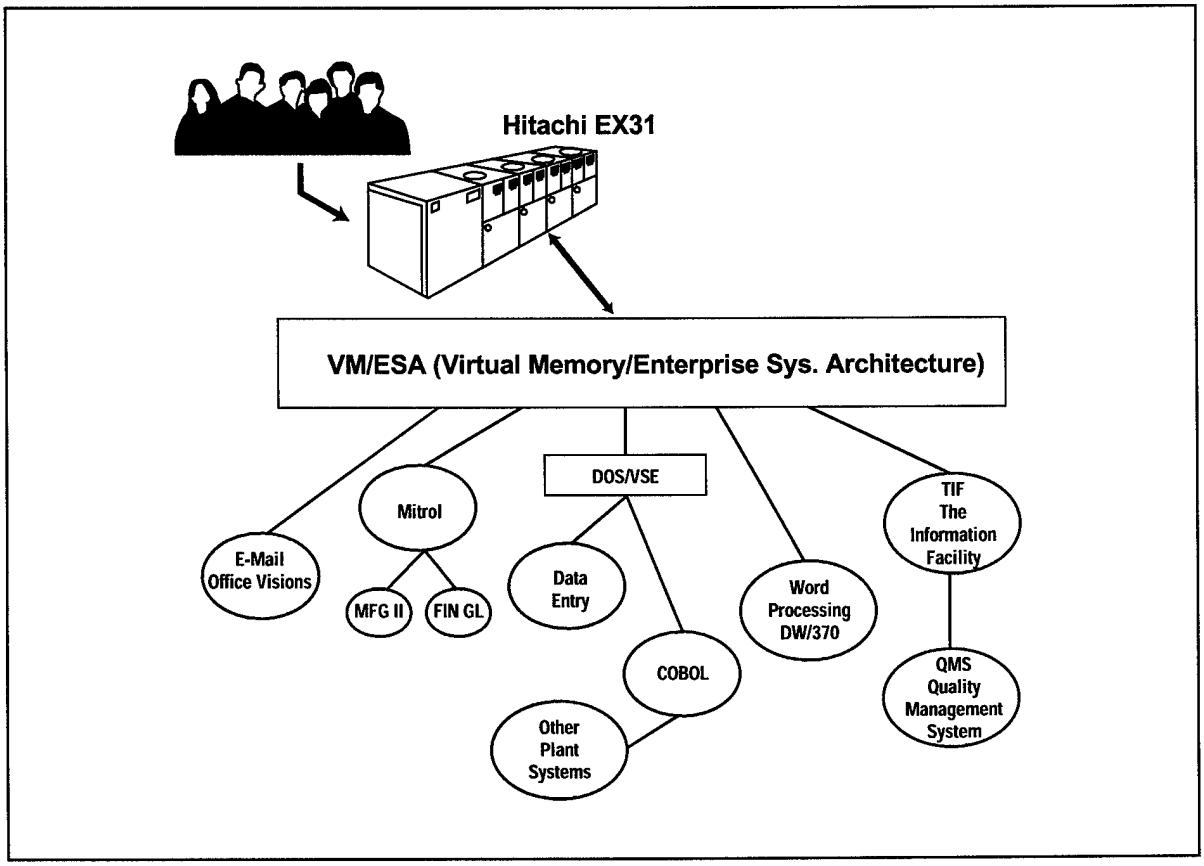


FIGURE 3-1. ADP SYSTEM CONFIGURATION

Computerized Explosives Compatibility System

By developing a computerized system to track explosives storage compatibility and quantities, M&H has minimized errors in material storage that may compromise plant safety. Safety regulations require that explosives be stored in segregated magazines based on their established compatibility grouping. The regulations also require that the quantity of explosives in a magazine be controlled based on the explosive's hazards classification. Verification that magazines were not overloaded or that incompatible materials were not stored together were previously accomplished by periodic inspections and regular physical inventories.

This new system takes hazardous classification and compatibility data supplied with the hazardous component safety data sheets, storage requirements from AMCR 385-100 (the Army's explosives safety manual), and the data from the material handlers on what has been stored or removed from each magazine. The system provides daily reports on the individual explosive weights in each building, the maximum amount that can be stored at the site, and highlights any deficiencies. Deficiencies tracked include incorrect storage mixing, no hazards classification or storage group assigned for the material, and overloaded conditions.

This system has proven effective in minimizing the time it takes to correct any errors in magazine storage. It has also increased the level of visibility to both operations and management personnel.

Electronic Procedure Approval

To reduce the cycle time required for Manufacturing Instructions (MIs) procedure approvals, Mason & Hanger has developed an electronic procedure approval system using the E-mail network. Previously, a manual approval route was required with one person at a time reviewing and signing off on procedures. Procedures had to be hand carried or sent through the plant mail system, and copies had to be generated and distributed throughout the plant. In some cases, delays caused lost time on the production line and impacted the schedule of the various programs.

To overcome these delays, Mason & Hanger now uses its E-mail system to gain electronic approval of all Manufacturing Instructions. The system provides an electronic "fill in the blank" form available to all users. This form provides all information for the procedure and when completed, goes directly to a typist for cleanup and proper formatting. The document is then sent electronically to all approvers for simultaneous signoff. Final approvals are received through the E-mail system and are entered in a log which is printed for objective evidence.

The cycle time for approval of Manufacturing Instructions had been reduced over the years but has shown an additional significant decline since the E-mail system initiation in 1991 (Figure 3-2). Generating between 500 to 600 MIs (including revisions) per year, Mason & Hanger has saved a significant amount of time through the use of the electronic procedure approvals.

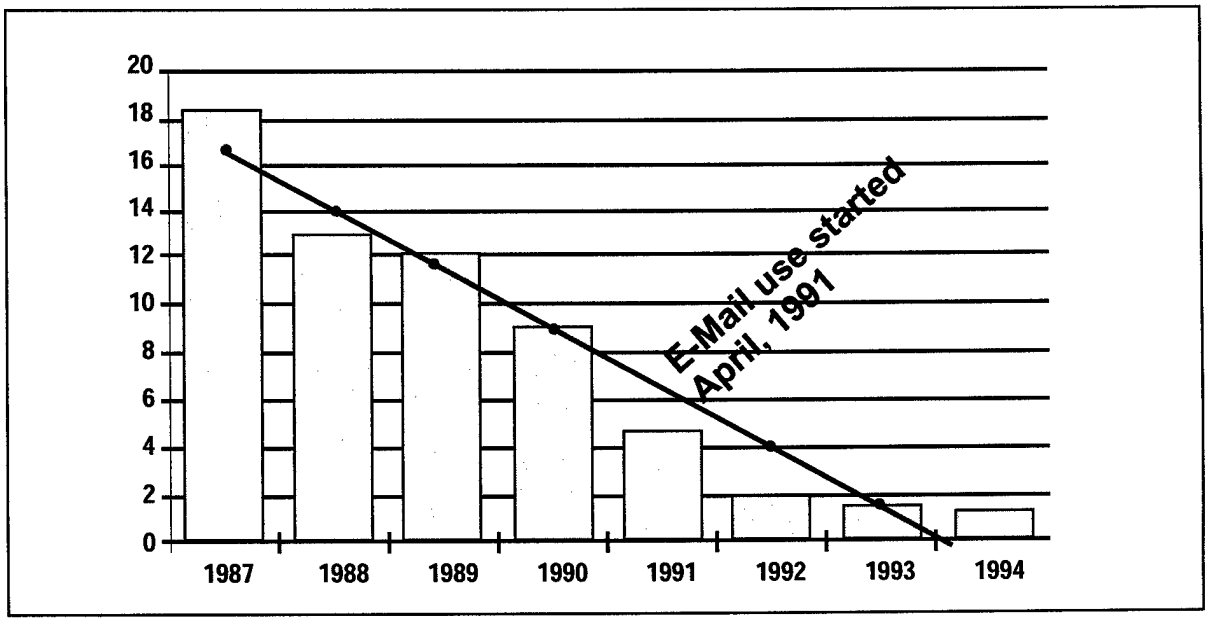


FIGURE 3-2. MANUFACTURING INSTRUCTION CYCLE TIME

Metrology Laboratory Recall System

Mason & Hanger has designed and implemented an in-house calibration recall system to meet the company's particular needs for gauge management. Prior to implementing the current system, two keypunch operators were required to input data on index cards for any updates or additions. This process was labor intensive and could not provide on-line notification of recall notices, resulting in many items violating their calibration due date. A study determined that no off-the-shelf systems were available at the time that would satisfy the requirements.

The new system is linked factory-wide and allows users to query information, run reports, and perform custom sorts for an item or group of items. The system's data is password-protected, and entries and deletions can only be performed by authorized personnel. The database contains information on over 6800 gauges, 2000 pieces of tooling and approximately 500 relief valves, all of which require calibration and recall at various times throughout their use to comply with MIL-STD-45662A and/or safety requirements. The new system has reduced the number of recall violations by over 50% and allows the production department to schedule its work in a manner to facilitate release of the recalled items prior to their expiration date.

The data used by the recall system can also be applied to develop performance indicators that help in the development and improvement of various processes throughout the facility.

3.4 LOGISTICS

LOGISTICS ANALYSIS/ DOCUMENTATION

Government Bill of Lading Transportation System

Mason & Hanger has automated its process for preparing the specialized Government Bill of Lading (GBL) documents required to ship explosive materials from the Iowa Army Ammunition Plant. GBL documents for explosive material require a number of informational data items to identify what is being shipped, who is the authorized transportation agent, and the approved transport route. Specifically, these include national stock numbers and security categories from the Army Master Data File, addresses from the DoD Activity Address Directory and Terminal Facility Guide of the cognizant military branch, freight classification nomenclatures from the Joint Hazard Classification System and Army Master Datafile Retrieval Microform System, and routing instruction notes in accordance with the Defense Traffic Management Regulation AR55-355 Appendix D.

Prior to 1984, all information was individually located in the appropriate guide and manually typed onto GBLs and shipping documents. A computer system is now used to automate preparation of the routine portions of the GBL forms, greatly reducing the time required to prepare the GBL forms as well as the chances for typographical errors. Data entry requirements typically include the original order for material (received via E-Mail), assigned lot and voucher numbers, and four-digit codes that identify specific routing and shipment clearance information. The computer then prints out the finalized shipping documents (DD-1348 or DD-1149), the GBL, and continuation sheets. Through the use of standardized data input screens and information codes, the total time required for preparation of a GBL document has been reduced from approximately one hour to 10 minutes.

3.5 MANAGEMENT

MANUFACTURING STRATEGY

Team Concepts

Mason & Hanger has applied the team concept since mid-1992 with the Materiel Division as one of the first internal organizations to adopt the team approach. Initial activities included the development of a division mission statement that recognized people as the division's principal asset and emphasized empowerment.

Before undertaking a team approach, many of the tools needed to support it, such as SPC and performance indicator, were in place and well understood as a result of effective training at M&H. Although this provided a foundation, very little training was presented in team building. Therefore, a learning-by-doing approach was adopted, and employees were encouraged to exercise initiative. They were required to find out and know contractual limitations and budgetary constraints and, within these bounds, were encouraged to test the waters of empowerment and allowed to take risks. Lessons learned from this effort highlighted that team building required major cultural changes that may not occur quickly or easily. Teams required time to mature and build trust.

A key objective of the team concept was then to move away from organizational structure and achieve a flat organization. The focus centered on team members interacting freely, organizing themselves, and accomplishing tasks with a minimum of direct supervision. One consequence was the disappearance of middle management as teams became self directing. M&H decided that some level

of middle management needed to remain in place until teams reached a sufficient level of maturity.

The two most important factors in adopting the team concept were leadership and communication. Effective leadership at M&H was essential to ensure that the teams kept developing and maturing and to provide for necessary accountability. Senior level management also needed to allow the process to mature by limiting the use of command decisions. Communication was probably the most important factor needed for success in adopting a team concept.

Strategic Planning

In the past, Mason & Hanger's strategic planning centered on large military ammunition contracts. This strategy has changed significantly because of defense spending cuts and newly defined customer needs. To develop a strategic plan that will address the future requirements of the organization, Mason & Hanger is developing its plan around the Malcolm Baldrige criteria and has divided it into three primary phases including the plan development, deployment and execution, and a feedback system to measure the results.

The plan development includes the vision statement, corporate policy, and white paper assessments of seven real-world factors such as national and international defense markets, defense ammunition business, emerging new defense technologies, the future business environment, customer and supplier relationships, the social and employee environment, and a thorough analysis of the competition. When completed, the plan's goal is to take M&H into the 21st century as its customers' premier supplier.

The deployment and execution of the plan is currently based on approximately 215 Strategic Elements (SEs). These SEs each have a single point of contact empowered to carry out the assigned element of the plan. To measure progress, Performance Indicators (PIs), have been developed and are linked to the SE's particular goals.

The feedback systems that track the progress and measure the plan's effectiveness include:

- Quarterly SE Days are day-long meetings held off-site to report progress on approximately 35 to 40 SEs. They are attended by the executive staff, random cross-section of the work force, and major customer representatives;
- Customer Surveys to provide important feedback on the needs of the customers and their issues;
- PIs developed around the particular goals of the SEs and used to monitor individual items' progress.

This new strategy is helping to transform Mason & Hanger into an outward focused, long range thinking organization that anticipates changes in processes and technologies as it moves into the 21st century.

PERSONNEL REQUIREMENTS

Ergonomics in the Workplace

M&H initiated an aggressive Ergonomic Improvement Program in 1987 to eliminate workplace conditions that posed biomechanical stress to the workers. The program started with the formation of a committee comprised of industrial engineering, process engineering, safety, and medical personnel, as well as production workers. The committee met monthly to review the working conditions of the various processes and to study any new future processes.

Some key elements that have evolved from this program include rotation of personnel with repetitive jobs, equipment design with the operator and the task in mind, redefined processes, and education of the employees. M&H also instituted a medical program to stress prevention by proper exercise and conditioning, as well as a treatment program that assists employees who are injured on the job.

Since 1987, the number of lost time repetitive motion cases has shown a steady decline with the exception of one year (Figure 3-3). This improvement is a direct result of recognizing the need to include ergonomics in the workplace. These concepts apply not only to new tasks, but also to the proven processes that may have been in place prior to some current solutions and equipment.

4-10s versus 5-8s Work Schedule

In February 1987, Mason & Hanger contemplated replacing the eight-hour, five-day work week with a ten-hour, four-day work week, driven by the knowledge that its competition had already instituted the change. During the next

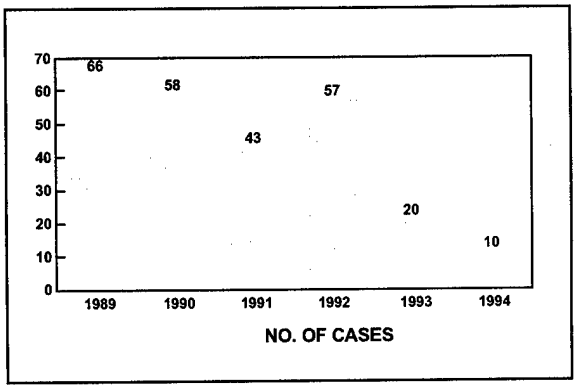


FIGURE 3-3. REPETITIVE MOTION CASES

24 months, Mason & Hanger conducted a thorough investigation of the ten-hour, four-day work week benefits through studies with other companies, polled the work force, and negotiated contracts with its bargaining units. All results indicated that the ten-hour, four-day work schedule would benefit the business, would be supported by the employees, and would be welcomed by the bargaining units.

In January 1989, the executive staff approved the change to the new work schedule. A Facilities Submission was forwarded to and approved by the Army's Armament Munitions and Chemical Command, and the transition was quickly accomplished. M&H then sent letters and notices to each employee outlining the new work schedule procedures. Suppliers and customers were also notified of the change.

The first six months tangible savings met the expectations of management through fewer equipment start-ups and shutdowns, less energy consumption of the central steam heating system, fewer test firings, reduction in maintenance overtime, a reduction of the professional medical staff on Fridays, and fuel savings for the fleet of 500 vehicles. Additionally, there was a per unit, man-hour decrease in 10 of 17 production items, a 26 percent decline in employee turnover, a reduction of 35,000 vehicle-miles, a 40% increase in contaminated waste processor productivity, and no change in employee absenteeism.

APPENDIX A

TABLE OF ACRONYMS

Acronym	Definition
AIDECS	Automated Inspection Device for Explosive Charge in Shell
AP&P	Administrative Practices and Procedures
BMP	Best Manufacturing Practices
BPRT	Business Process Reengineering Team
GBL	Government Bill of Lading
IAAP	Iowa Army Ammunition Plant
IBC	International Benchmarking Clearinghouse
IE	Industrial Engineer
IMIS	Integrated Management Information System
M&H	Mason & Hanger
MI	Manufacturing Instruction
ME	Methods Engineering
PAT	Process Action Team
PI	Performance Indicator
QMS	Quality Management System
SE	Strategic Element
TBE	The Benchmarking Exchange
VECP	Value Engineering Change Proposal
VE	Value Engineering

APPENDIX B

BMP SURVEY TEAM

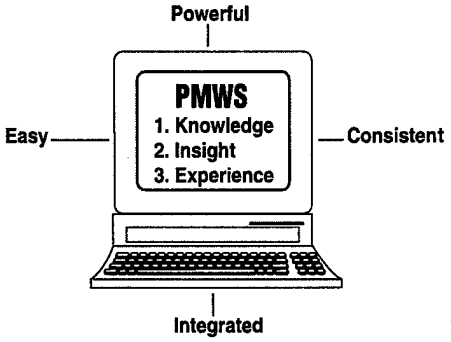
Team Member	Agency	Function
Bob Jenkins (703) 602-3003	**NAVSEA** Washington, DC	**Team Chairman**
Amy Scanlan (703) 271-9055	**BMP Representative** Washington, DC	**Technical Writer**
Team A		
Don Hill (317) 353-3781	**Naval Air Warfare Center** **Aircraft Division - Indianapolis** Indianapolis, IN	**Team Leader**
Jack Tamargo (7077) 646-57881	**Mare Island Naval Shipyard** Vallejo, CA	
John Brough (301) 743-4417	**Naval Surface Warfare Center** **Indian Head Division** Indian Head, MD	
Team B		
Rick Purcell (703) 271-9055	**BMP Representative** Washington, DC	**Team Leader**
Larry Halbig (317) 353-3838	**Naval Air Warfare Center** **Aircraft Division - Indianapolis** Indianapolis, IN	
Kip Hoffer (812) 854-3240	**Crane Division** **Naval Surface Warfare Center** Crane, IN	

APPENDIX C

PROGRAM MANAGER'S WORKSTATION

The Program Manager's Workstation (PMWS) is a series of expert systems that provides the user with knowledge, insight, and experience on how to manage a program, address technical risk management, and find solutions that industry leaders are using to reduce technical risk and improve quality and productivity. This system is divided into four main components; KNOW-HOW, Technical Risk Identification and Mitigation System (TRIMS), BMP Database, and Best Manufacturing Practices Network (BMPNET).

- **KNOW-HOW** is an intelligent, automated method that turns "Handbooks" into expert systems, or digitized text. It provides rapid access to information in existing handbooks including Acquisition Streamlining, Non-Development Items, Value Engineering, NAVSO P-6071 (Best Practices Manual), MIL- STD-2167/2768, SecNav 5000.2A and the DoD 5000 series documents.



PROGRAM MANAGER'S WORKSTATION

- **TRIMS** is based on DoD 4245.7-M (the transition templates), NAVSO P-6071 and DoD 5000 event oriented acquisition. It identifies and ranks the high risk areas in a program. TRIMS conducts a full range of risk assessments throughout the acquisition process so corrective action can be initiated before risks develop into problems. It also tracks key project documentation from concept through production including goals, responsible personnel, and next action dates for future activities in the development and acquisition process.

- The **BMP Database** draws information from industry, government, and the academic communities to include documented and proven best practices in design, test, production, facilities, management, and logistics. Each practice in the database has been observed and verified by a team of experienced government engineers. All information gathered from BMP surveys is included in the BMP Database, including this survey report.

- **BMPNET** provides communication between all PMWS users. Features include downloading of all programs, E-mail, file transfer, help "lines", Special Interest Groups (SIGs), electronic conference rooms and much more. Through BMPNET, IBM or compatible PC's and Macintosh computers can run all PMWS programs.

- To access **BMPNET** efficiently, users need a special modem program. This program can be obtained by calling the BMPNET using a VT-100/200 terminal emulator set to 8,N,1. Dial (703) 538-7697 for 2400 baud modems and (703) 538-7267 for 9600 baud and 14.4 kb. When asked for a user profile, type: DOWNPC or DOWNMAC <return> as appropriate. This will automatically start the Download of our special modem program. You can then call back using this program and access all BMPNET functions. The General User account is:

  USER PROFILE: BMPNET

  USER I.D.: BMP

  Password: BMPNET

If you desire your own personal account (so that you may receive E-Mail), just E-Mail a request to either Ernie Renner (BMP Director) or Brian Willoughby (CSC Program Manager). If you encounter problems please call (703) 538-7799.

APPENDIX D

NAVY CENTERS OF EXCELLENCE

Automated Manufacturing Research Facility
(301) 975-3414

The Automated Manufacturing Research Facility (AMRF) – a National Center of Excellence – is a research test bed at the National Institute of Standards and Technology located in Gaithersburg, Maryland. The AMRF produces technical results and transfers them to the Navy and industry to solve problems of automated manufacturing. The AMRF supports the technical work required for developing industry standards for automated manufacturing. It is a common ground where industry, academia, and government work together to address pressing national needs for increased quality, greater flexibility, reduced costs, and shorter manufacturing cycle times. These needs drive the adoption of new computer-integrated manufacturing technology in both civilian and defense sectors. The AMRF is meeting the challenge of integrating these technologies into practical, working manufacturing systems.

Electronics Manufacturing Productivity Facility
(317) 226-5607

Located in Indianapolis, Indiana, the Electronics Manufacturing Productivity Facility (EMPF) is a National Center of Excellence established to advance state-of-the-art electronics and to increase productivity in electronics manufacturing. The EMPF works with industry, academia, and government to identify, develop, transfer, and implement innovative electronics manufacturing technologies, processes, and practices. The EMPF conducts applied research, development, and proof-of-concept electronics manufacturing and design technologies, processes, and practices. It also seeks to improve education and training curricula, instruction, and necessary delivery methods. In addition, the EMPF is striving to identify, implement, and promote new electronics manufacturing technologies, processes, materials, and practices that will eliminate or reduce damage to the environment.

National Center for Excellence in Metalworking Technology
(814) 269-2420

The National Center for Excellence in Metalworking Technology (NCEMT) is located in Johnstown, Pennsylvania and is operated by Concurrent Technologies Corporation (CTC), a subsidiary of the University of Pittsburgh Trust. In support of the NCEMT mission, CTC's primary focus includes working with government and industry to develop improved manufacturing technologies including advanced methods, materials, and processes, and transferring those technologies into industrial applications. CTC maintains capabilities in discrete part design, computerized process analysis and modeling, environmentally compliant manufacturing processes, and the application of advanced information science technologies to product and process integration.

Center of Excellence for Composites Manufacturing Technology
(414) 947-8900

The Center of Excellence for Composites Manufacturing Technology (CECMT), a national resource, is located in Kenosha, Wisconsin. Established as a cooperative effort between government and industry to develop and disseminate this technology, CECMT ensures that robust processes and products using new composites are available to manufacturers. CECMT is operated by the Great Lakes Composites Consortium. It represents a collaborative approach to provide effective advanced composites technology that can be introduced into industrial processes in a timely manner. Fostering manufacturing capabilities for composites manufacturing will enable the U.S. to achieve worldwide prominence in this critical technology.

Navy Joining Center
(614) 486-9423

The Navy Joining Center (NJC) is a Center of Excellence established to provide a national resource for the development of materials joining expertise, deployment of emerging manufacturing technologies, and dissemination of information to Navy contractors, subcontractors, Navy activities, and U.S. industry.

The NJC is located in Columbus, Ohio, and is operated by Edison Welding Institute (EWI), the nation's largest industrial consortium dedicated to materials joining. The NJC combines these resources with an assortment of facilities and demonstrated capabilities from a team of industrial and academic partners. NJC technical activities are divided into three categories - Technology Development, Technology Deployment, and Technology Transfer. Technology Development maintains a goal to complete development quickly to initiate deployment activities in a timely manner. Technology Deployment includes projects for rapid deployment teaming and commercialization of specific technologies. The Technology Transfer department works to disseminate pertinent information on past and current joining technologies both at and above the shop floor.

APPENDIX E

NEW BEST MANUFACTURING PRACTICES PROGRAM TEMPLATES

Since 1985, the BMP Program has applied the templates philosophy with well-documented benefits. Aside from the value of the templates, the templates methodology has proven successful in presenting and organizing technical information. Therefore, the BMP program is continuing this existing "knowledge" base by developing 17 new templates that complement the existing DoD 4245.7-M or Transition from Design to Production templates.

The development of these new templates was based in part on Defense Science Board studies that have identified new technologies and processes that have proven successful in the last few years. Increased benefits could be realized if these activities were made subsets of the existing, compatible templates.

Also, the BMP Survey teams have become experienced in classifying Best Practices and in technology transfer. The Survey team members, experts in each of their individual fields, determined that data collected, while related to one or more template areas, was not entirely applicable. Therefore, if additional categories were available for Best Practices "mapping," technology transfer would be enhanced.

Finally, users of the Technical Risk Identification and Mitigation System (TRIMS) found that the program performed extremely well in tracking most key program documentation. However, additional categories – or templates – would allow the system to track all key documentation.

Based on the above identified areas, a core group of activities was identified and added to the "templates baseline." In addition, TRIMS was modified to allow individual users to add an unlimited number of user-specific categories, templates, and knowledge-based questions.

APPENDIX F

COMPLETED SURVEYS

BMP surveys have been conducted at the companies listed below. Copies of older survey reports may be obtained through DTIC or by accessing the BMPNET. Requests for copies of recent survey reports or inquiries regarding the BMPNET may be directed to:

Best Manufacturing Practices Program
4321 Hartwick Rd.
Suite 308
College Park, MD 20740
Attn: Mr. Ernie Renner, Director
Telephone: 1-800-789-4267
FAX: (301) 403-8180

COMPANIES SURVEYED

Litton
Guidance & Control Systems Division
Woodland Hills, CA
October 1985 and February 1991

Texas Instruments
Defense Systems & Electronics Group
Lewisville, TX
May 1986 and November 1991

Harris Corporation
Government Support Systems Division
Syosset, NY
September 1986

Control Data Corporation
Government Systems Division
(Computing Devices International)
Minneapolis, MN
December 1986 and October 1992

ITT
Avionics Division
Clifton, NJ
September 1987

UNISYS
Computer Systems Division
(Paramax)
St. Paul, MN
November 1987

Honeywell, Incorporated
Undersea Systems Division
(Alliant Tech Systems, Inc.)
Hopkins, MN
January 1986

General Dynamics
Pomona Division
Pomona, CA
August 1986

IBM Corporation
Federal Systems Division
Owego, NY
October 1986

Hughes Aircraft Company
Radar Systems Group
Los Angeles, CA
January 1987

Rockwell International Corporation
Collins Defense Communications
Cedar Rapids, IA
October 1987

Motorola
Government Electronics Group
Scottsdale, AZ
March 1988

General Dynamics
Fort Worth Division
Fort Worth, TX
May 1988

Hughes Aircraft Company
Missile Systems Group
Tucson, AZ
August 1988

Litton
Data Systems Division
Van Nuys, CA
October 1988

McDonnell-Douglas Corporation
McDonnell Aircraft Company
St. Louis, MO
January 1989

Litton
Applied Technology Division
San Jose, CA
April 1989

Standard Industries
LaMirada, CA
June 1989

Teledyne Industries Incorporated
Electronics Division
Newbury Park, CA
July 1989

Lockheed Corporation
Missile Systems Division
Sunnyvale, CA
August 1989

General Electric
Naval & Drive Turbine Systems
Fitchburg, MA
October 1989

TRICOR Systems, Incorporated
Elgin, IL
November 1989

TRW
Military Electronics and Avionics Division
San Diego, CA
March 1990

Texas Instruments
Defense Systems & Electronics Group
Dallas, TX
June 1988

Bell Helicopter
Textron, Inc.
Fort Worth, TX
October 1988

GTE
C^3 Systems Sector
Needham Heights, MA
November 1988

Northrop Corporation
Aircraft Division
Hawthorne, CA
March 1989

Litton
Amecom Division
College Park, MD
June 1989

Engineered Circuit Research, Incorporated
Milpitas, CA
July 1989

Lockheed Aeronautical Systems Company
Marietta, GA
August 1989

Westinghouse
Electronic Systems Group
Baltimore, MD
September 1989

Rockwell International Corporation
Autonetics Electronics Systems
Anaheim, CA
November 1989

Hughes Aircraft Company
Ground Systems Group
Fullerton, CA
January 1990

MechTronics of Arizona, Inc.
Phoenix, AZ
April 1990

Boeing Aerospace & Electronics
Corinth, TX
May 1990

Textron Lycoming
Stratford, CT
November 1990

Naval Avionics Center
Indianapolis, IN
June 1991

Kurt Manufacturing Co.
Minneapolis, MN
July 1991

Raytheon Missile Systems Division
Andover, MA
August 1991

Tandem Computers
Cupertino, CA
January 1992

Conax Florida Corporation
St. Petersburg, FL
May 1992

Hewlett-Packard
Palo Alto Fabrication Center
Palo Alto, CA
June 1992

Digital Equipment Company
Enclosures Business
Westfield, MA and
Maynard, MA
August 1992

NASA Marshall Space Flight Center
Huntsville, AL
January 1993

Department of Energy-
Oak Ridge Facilities
Operated by Martin Marietta Energy Systems, Inc.
Oak Ridge, TN
March 1993

Technology Matrix Consortium
Traverse City, MI
August 1990

Norden Systems, Inc.
Norwalk, CT
May 1991

United Electric Controls
Watertown, MA
June 1991

MagneTek Defense Systems
Anaheim, CA
August 1991

AT&T Federal Systems Advanced
Technologies and AT&T Bell Laboratories
Greensboro, NC and Whippany, NJ
September 1991

Charleston Naval Shipyard
Charleston, SC
April 1992

Texas Instruments
Semiconductor Group
Military Products
Midland, TX
June 1992

Watervliet U.S. Army Arsenal
Watervliet, NY
July 1992

Naval Aviation Depot
Naval Air Station
Pensacola, FL
November 1992

Naval Aviation Depot
Naval Air Station
Jacksonville, FL
March 1993

McDonnell Douglas Aerospace
Huntington Beach, CA
April 1993

Crane Division
Naval Surface Warefare Center
Crane, IN and Louisville, KY
May 1993

R. J. Reynolds Tobacco Company
Winston-Salem, NC
July 1993

Hamilton Standard
Electronic Manufacturing Facility
Farmington, CT
October 1993

Harris Semiconductor
Melbourne, FL
January 1994

Naval Undersea Warfare Center
(NUWC) Division Keyport
Keyport, WA
May 1994

Philadelphia Naval Shipyard
Philadelphia, PA
June 1993

Crystal Gateway Marriott Hotel
Arlington, VA
August 1993

Alpha Industries, Inc
Methuen, MA
November 1993

United Defense, L.P.
Ground Systems Division
San Jose, CA
March 1994

Mason & Hanger
Silas Mason Co., Inc.
Middletown, IA
July 1994